THERMAL STABILITY

Purpose

What is the purpose of this experiment?

(The purpose of this experiment is to demonstrate the thermal stability of a clay mineral — vermiculite — and to compare the differences in thermal stability between two different types of vermiculite.)

Hypothesis:

State your hypothesis regarding the thermal stability of the clay mineral vermiculite. Be sure to mention how you expect the KCl-saturated vermiculite to differ from the untreated vermiculite.
(Answers will vary but encourage students to be as specific as possible.)

Materials:

2 aluminum pans

candles

drying oven

pot holder

flake vermiculite

saturated KCl (table salt substitute) solution

two 250 mL beakers (or oven-safe containers)

Procedure:

1. Label beakers A and B.

2. Fill beaker A about half way with water. Make a saturated solution of KCl by pouring the KCl into the water and stirring to dissolve it. Continue adding the KCl and stirring until solid that will not dissolve remains at the bottom of the beaker.

3. Make some potassium saturated vermiculite by placing a small amount of the flake vermiculite in beaker A with the saturated KCl solution. Place the same amount of vermiculite in the empty beaker. By soaking the vermiculite in the KCl solution, you are allowing potassium cations to replace the naturally occurring magnesium cations in the interlayer of the mineral's structure.

4. Allow the vermiculite to soak in the KCl solution for at least 48 hours. Then pour off the liquid and spread the vermiculite in both beakers on separate cookie sheets and dry it in an oven set at 110 °C (approximately 225 °F). This will take 2-3 hours. Stir the drying vermiculite occasionally.

5. Using the oven-dried samples of Mg^{2+}-saturated and the K^{+}-saturated vermiculite, place a few flakes of each in separate aluminum pans.

6. Light the candle. Using the pot holder to protect your hands place the clay-containing pans over the hottest part of the flame. Observe and record the changes in the clay.

Observations:

Describe the K^{+}-saturated vermiculite.

Before drying:

_____

_____

After drying:

_____

_____

During and/or after exposure to heat:

_____

_____

Describe the Mg^{2+}-saturated vermiculite (untreated).

Before drying:

_____

_____

After drying:

_____

_____

During and/or after exposure to heat:

_____

Conclusion:

1. Do the two types of clay behave differently? If so, how are they different and how can that explain their different behaviors?

(Yes. The untreated vermiculite is saturated with Mg^{2+} ions. K^{+} ions have taken the place of the Mg^{2+} ions in the vermiculite saturated with KCl. Because the Mg^{2+} saturated vermiculite holds its waters of hydration more strongly than the K^{+} saturated vermiculite, there is more water incorporated into its structure. The greater amount of water available leads to a greater degree of thermal stability.)

2. What is the source of the heat that must be considered when planning and designing the repository?

(The radioactive decay of spent fuel produces thermal heat. A major technical problem that has to be dealt with in siting the repository is the effect of heat from the radioactive decay process on the rock in which the repository will be located.)

3. Why is it necessary to consider thermal stability of potential repository minerals?

(The loss of thermal stability of repository minerals may reduce their sorption and ion exchange capabilities. The water released from some minerals during thermal alteration may also have a cooling effect on the thermal heat produced by decaying spent fuel but may also have corrosive effects on the waste-containing canister.)